A Method for Increasing Osprey Productivity

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Abstract: Seven (three control, four experimental) clutches of Osprey eggs were collected to determine if eggs that normally would not hatch in the wild, would hatch in an incubator in the laboratory where the factors of breakage and predation were eliminated, and to determine if the adults would attempt a second nesting. None of the experimental eggs hatched, thus indicating that some factor intrinsic to the egg is the cause of failure. Control eggs hatched with normal frequency. Of the seven pairs of Ospreys from which clutches were collected, five pairs renested and four of these pairs produced seven young. Hatching rate increased from the first nesting (23.8%) to the second nesting (53.8%), though clutch size was smaller (3.00 vs. 2.60 eggs per clutch) for the second clutch. Because of the apparent higher hatching rate of second clutches, renesting experiments may prove to be useful in future Osprey management programs.

A decline in populations of the Osprey (*Pandion haliaetus*) has recently been reported in Maine (Kury 1966), Massachusetts (Fernandez pers. comm.), Connecticut (Ames and Mersereau 1964), New York (Spitzer unpubl. data), New Jersey (Schmid 1966), Maryland (Wiemeyer 1971), Virginia (Kennedy 1971), Michigan (Postupalsky 1969), Wisconsin (Berger and Mueller 1969), and Minnesota (Dunstan 1968). Failure of eggs to hatch has frequently been cited as the cause for this decline (Ames and Mersereau 1964; Ames 1966; Wiemeyer 1971).

Recent investigations, designed to discover the causes of egg failure and to find ways of preventing the decline of these populations, have taken advantage of the Ospreys' ability to tolerate human interference. Spitzer (unpubl. data), by transferring clutches from nests in a stable Maryland population to nests in a declining Connecticut population, and vice versa, has found that the hatching rate for the switched eggs equaled that normally found in the area in which the eggs were laid. This finding demonstrated that some defect in the egg itself results in its failure to hatch, rather than this being due to some extrinsic factor such as abnormal parental behavior. In an attempt to increase New England populations, Spitzer (unpubl. data) and Fernandez (pers. comm.) have transplanted nestlings and eggs from the Chesapeake Bay to selected nests in their study areas in Connecticut and Massachusetts. The populations in the Chesapeake Bay have been considered relatively stable, but recent surveys by Wiemeyer (1971) and Kennedy (1971) demonstrate that some of the Chesapeake Bay Ospreys are producing fewer young than Henny and Wight (1969) consider necessary for continued stability. Because of this, removal of eggs and nestlings may be exerting additional pressure on the Chesapeake populations, thus hastening their decline.

The primary purpose of the investigation reported here was to devise a method for increasing productivity, so that surplus young could continue to be transported to areas where populations are in decline. The procedure was also designed to determine whether eggs collected from nests in which no young had hatched in previous years, due to disappearance or breakage of the eggs, would hatch under controlled incubator conditions where external pressures were eliminated.

MATERIALS AND METHODS

Seven clutches of eggs were collected from nests in three different tidal areas of Virginia, on 10, 11, and 15 April 1971, and were artificially incubated. Three clutches were taken from nests near New Point Comfort, Virginia. Young had been reared in these nests in 1970, and these nests were designated as the control group. Two clutches were collected from each of two other study areas, the James River and the York River. Eggs from these nests had not hatched in 1970 and, in fact, had disappeared from these nests before completion of the incubation period. These four clutches made up the experimental group. Because the adults from these nests were not color-banded, it had to be assumed that the same pair occupied the same nest each year, a habit which is characteristic of Ospreys (Bent 1937). Thus, the experiment was designed: (1) to determine whether or not the eggs in the experimental group would hatch if breakage and predation were eliminated; (2) to see if adults, whose first eggs were removed, would lay a second clutch; and (3) to determine clutch size and hatching success in the second clutch, for comparison of these factors to the first clutch.

A case for the transportation of eggs from nests to an incubator was designed after that used at the Patuxent Wildlife Research Center (Wiemeyer pers. comm.). The case consisted of a suitcase lined with foam rubber, with holes the size of Osprey eggs made in the rubber. Two hot water bottles provided heat, and an internal temperature of approximately 99°F was maintained and regulated by opening the case to reduce heat and refilling the hot water bottles to increase heat.

A Favorite Electric Cabinet Incubator, built by the Leahy Manufacturing Company, was used in this experiment. Circulated air temperature was maintained between 99° and 100°F. The humidity initially was kept at 68% and was gradually increased to a maximum of 73% by the end of the incubation period. Eggs were turned 180° by hand, three times daily, at 7:00 a.m., 3:00 p.m., and 10:00 p.m. Ventilation holes in the incubator were kept one-fourth open, starting 10 days before the first egg was expected to hatch. The time between the collection of the eggs and their placement in the incubator never exceeded 4 hours.

When two of the eggs in the control group began "pipping," they were placed in an active nest in the York River study area. The three eggs already present in this nest were placed in the incubator to complete their incubation period. Young hatching from these latter eggs were allowed to dry in the incubator for several hours and were then transferred to an artificial Osprey nest in an environmental growth chamber, where the humidity was 50% and the temperature was 92°F. At first, the temperature was lowered about 3° every 2 days, but after 10 days, the temperature was lowered to 75°F, with no apparent discomfort to the young.

When the young were 2 days old, they were fed small pieces of chopped fish which had been dipped into cod liver oil. At first the young were reluctant to eat, but after being force-fed for a time, soon ate anything they were offered. An imitation of an Osprey whistle was used to trigger the feeding response. The young were fed four times daily, at 8:00 a.m., 12:00 noon, 4:00 p.m., and 8:00 p.m.

In the incubation experiment, the student's *t*-test for unpaired data was used to compare percentages of eggs hatching. Differences were considered significant at $P<0.05$.

RESULTS

The results of the incubation and renesting experiment are summarized in Table 1. Hatching success for the controls (1.67 young per nest) was identical to that of eggs noted from the same nests in 1970. However, the hatching rate was lower than the average of 2.00 young per productive pair found in 22 nests within this study area. None of the eggs in the experimental group hatched, and the percentage of eggs with obvious embryonic development was significantly lower ($P<0.01$) than in the controls.

Of the five young hatched in the control group, two hatched successfully in the laboratory, but due to improper facilities after hatching, died of heat exhaustion. The third and fourth eggs, upon pipping, were taken

TABLE 1. Results of the incubation and renesting experiments.

Nest no.	1st Nesting: Clutch size	% with obvious embryonic development	% reaching hatching stage	Young per 1st nest	2nd Nesting: Renest	Clutch size	% Reaching hatching stage	Young per renest
Control Group								
New Point Comfort 1	4	100	50	2	Yes	3	67	2
New Point Comfort 2	3	100	33	1	Yes	2	100	2
New Point Comfort 3	3	67	67	2	Yes	3	67	2
Average	3.33	90	50	1.67	3/3	2.67	75	2
Experimental Group								
York River 1	3	0	0	0	Yes	3	0	0
York River 2	3	33	0	0	Yes	2	50	1
James River 1	3 (4)[a]	0	0	0	No	—	—	—
James River 2	2 (3)	50	0	0	No	—	—	—
Average	2.75 (3.25)	18	0	0	2/4	2.50	20	.50
Total Average	3.00 (3.29)	52	24	0.71	5/7	2.60	54	1.40

[a]One egg found after collection was thought to be the final egg of the first clutch. Numbers in parentheses are adjusted to include the final egg.

to a nest in the York River study area in order to prevent their loss, and they both hatched. One nestling disappeared when it was one week old, and the second fledged. The fifth egg reached the pipping stage, but the young bird died of an unknown cause before completely hatching.

Two of the three eggs taken from the York River nest hatched and the young were raised successfully in the environmental growth chamber, as described above. When these two young reached 12 and 16 days old, respectively, they were introduced into separate nests on the York River where they eventually fledged.

In five of the seven nests, the adults laid second clutches. About 3 weeks elapsed between removal of the first clutch and the laying of the second. The eggs collected from the James River nests may not have constituted full clutches because upon examination 4 weeks after the collection of the first clutch, each of these nests contained a single egg, which may have been the last eggs of the first clutches.

Although the average clutch size per nesting decreased from 3.00 to 2.60 eggs, hatching success improved greatly. In the control group, six out of eight eggs (75%) hatched, while in the experimental group, one out of five eggs (20%) hatched. The average number of young produced per nesting attempt almost doubled, being 0.71 for the first attempt and 1.40 for the second. In the control group, the combined total number of young produced for the first and second nestings was 11 young, or 3.67 young per productive breeding pair.

DISCUSSION

The incubation experiment clearly indicated that the experimental eggs would not hatch, even if the eggs had been exposed to possibly harmful external effects. This finding supports the conclusion drawn by Spitzer (unpubl. data), that factors intrinsic to the egg are the major cause for poor reproductive success in the Osprey. The small number of eggs with obvious embryonic development suggests that these eggs may never have been fertilized. However, because many of these eggs were found to be badly decomposed at the time they were opened, signs of embryonic development may have been obliterated, since Ames (1966) reported a minimum of 73% fertilization in 15 fresh Connecticut eggs, and a minimum of 93% fertilization in 31 Maryland eggs. A high percentage of fertilized eggs was also found by Spitzer (unpubl. data), who reported that six out of nine eggs from Connecticut contained embroys.

Tyrrell (1936), Ames (1966), and Reese (1970) have reported that Ospreys will lay a second clutch of eggs if the first clutch has been lost. This occurred in nests in which the first eggs were lost or taken in early spring (Ames 1966), from 28-29 April (Tyrrell 1936), and from 27-28 May (Reese 1970). Reese (1970) also reported that seven pairs of birds which had lost their nests during a wind storm on 8 May 1967 did not attempt a second nesting. Therefore, in order to increase the likelihood of the birds' producing a second clutch, in this investigation eggs were collected as early in the season as possible, on 10, 11, and 15 April 1971. Although Ames (1966) did not state how many pairs nested again, Tyrrell (1936) found that seven out of eight nests which had lost their first clutches contained a second set of eggs, while Reese (1970) found second clutches in 10 out of 16 cases. In the present study, five of seven pairs produced a second clutch. In all these cases, the second clutch averaged smaller (2.0 for Tyrrell 1936; 2.6 for Reese 1970, and this study) than the first clutch (3.0). In Reese's and Ames' studies, the hatching success in the second nestings was equal to or less than that of the first nestings, but in the present study, the percentage of eggs hatching increased from 24% in the first clutch to 54% in the second clutch. The poorer hatching success for second nestings reported by Reese and Ames may be due to the fact that the first clutches had been lost later in the season or, perhaps, may have involved the past hatching histories of these nests.

The method used in this study could provide a means by which declining Osprey populations might be sustained. The average of 1.40 young per nest in the second nesting attempt exceeds the 1.22-1.30 young per nest considered by Henny and Wight (1969) to be necessary for maintenance of a stable population. For the total experiment, an average of 1.70 young per breeding pair reached the hatching stage. This figure agrees with data from an earlier study, where an average of 1.60 young per nest were produced in 1934, at Smith's Point, Virginia (Tyrrell 1936, cited in Postupalsky 1969).

If a similar program were conducted on a larger scale, the number of young Ospreys produced in an area could be greatly increased. Such a program could be performed by collecting a large number of clutches from nests in which young have been produced for several years in a row, and allowing the adults to produce a second brood. These eggs could be placed in an incubator with the specified temperature and humidity described earlier, or in nests in which young had not been produced in years past. When the latter choice is taken, eggs from these nests with a history of poor reproductive success should also be placed in an incubator. If these eggs begin "peeping," it is recommended that they immediately be transferred to a nest where an unproductive pair are still incubating unviable eggs. This procedure prevents the arduous task of caring for the young after hatching in the laboratory. If young which hatch from the first clutches are to be transferred elsewhere, it is suggested that they remain with their foster parents for about one week in order to insure their survival.

Table 1 shows that one young was reared in a second nesting attempt by an experimental pair in the York River study area. If DDE is the cause of the failure of eggs to hatch, as argued by Heath et al. (1969), and of thin eggshells (Anderson et al. 1969; Peakall 1970; Bitman et al. 1970), then perhaps the failure of the eggs in the experimental group was caused by this compound. Ludwig and Tomoff (1966), working with Herring Gulls (*Larus argentatus*) and Prestt (1970), working with Grey Herons (*Ardea cinerea*), have shown that populations of these species, which are subject to egg loss and breakage in the first clutch, have higher nesting success with the second attempt. These observations, coupled with higher renesting success in both control and experimental pairs of Ospreys described in this paper, suggest that concentration of DDE in the body of the female may decrease with each egg laid. If this is so, it follows that the last egg laid would contain the lowest level of DDE. If the environment were not heavily contaminated with DDE, concentrations in the female might not increase during the 21 days before the second clutch was produced, and eggs in this clutch might contain still lower levels of DDE and might have a greater chance of hatching. Supporting evidence for this hypothesis was provided by Anderson et al. (1969), who showed that in the Double-crested Cormorant (*Phalacrocorax auritus*), eggs in second clutches not only had lower average levels of DDE but thicker eggshells as well. This hypothesis could be tested in Ospreys by marking each egg as it is laid, collecting both the first and second clutches, and measuring the weight, thickness, and the levels of pesticides and heavy metals in the eggs. If the second clutch was found to be less contaminated, removal of the first clutch in Ospreys and other species affected by environmental pollution might become standard procedure, provided that hatching and fledging rates increase.

One factor should be considered before either of the two programs mentioned above is undertaken. As a result of natural selection, the Osprey, like other species, lays its eggs at the time of the year most favorable for survival of the young. If the first clutch were removed, the fledging date for the second brood would be 4-5 weeks later than normal. Therefore, if eggs are collected, they should be taken as early as possible so that there is a sufficiently long period between fledging and fall migration.

It is suggested that the methods and program described in this paper might be utilized to help arrest the present decline in Osprey populations long enough to allow the level of environmental contamination to be reduced, so that the Osprey may once again reproduce at normal rates without the assistance of man.

LITERATURE CITED

AMES, P. L. 1966. DDT residues in the eggs of the Osprey in the northeastern United States and their relation to nesting success. *J. Appl. Ecol.* **3**(Suppl.):85-95.

AMES, P. L., and G. S. MERSEREAU. 1964. Some factors in the decline of the Osprey in Connecticut. *Auk* **81**:173-185.

ANDERSON, D. W., J. J. HICKEY, R. W. RISEBROUGH, D. F. HUGHES, and R. E. CHRISTENSEN. 1969. Significance of chlorinated hydrocarbon residues to breeding pelicans and cormorants. *Can. Field Nat.* **83**(2):91-112.

BENT, A. C. 1937. Life histories of North American birds of prey. *U.S. Natl. Mus. Bull.* **167**:352-379.

BERGER, D. D., and H. C. Mueller. 1969. Ospreys in northern Wisconsin. Pages 340-341 *in* J. J. Hickey, ed. Peregrine Falcon populations. Univ. Wisconsin Press, Madison.

BITMAN, J., H. C. CECIL, and G. F. FRIES. 1970. DDT-induced inhibition of avian shell gland carbonic anhydrase: a mechanism for thin eggshells. *Science* **168**:594-595.

DUNSTAN, T. C. 1968. Breeding success of Ospreys in Minnesota from 1963 to 1968. *Loon* **40**(4):109-112.

HEATH, R. G., J. W. SPANN, and J. F. KREITZER. 1969. Marked DDE impairment of Mallard reproduction in controlled studies. *Nature* **224**:47-48.

HENNY, C. J., and H. M. WIGHT. 1969. An endangered Osprey population: estimates of mortality and production. *Auk* **86**:188-198.

KENNEDY, R. S. 1971. Population dynamics of Ospreys in Tidewater Virginia, 1970-1971. M.S. Thesis. College of William and Mary, Williamsburg, Va.

KURY, C. R. 1966. Osprey nesting survey. *Wilson Bull.* **78**(4):470.

LUDWIG, J. P., and C. S. TOMOFF. 1966. Reproductive success and insecticide residues in Lake Michigan Herring Gulls. *Jack-Pine Warbler* **44**:77-85.

PEAKALL, D. B. 1970. p,p'DDT: effect on calcium and concentration of estradiol in the blood. *Science* **168**:592-594.

POSTUPALSKY, S. 1969. The status of the Osprey in Michigan in 1965. Pages 338-340 *in* J. J. Hickey, ed. Peregrine Falcon populations. Univ. Wisconsin Press, Madison.

PRESTT, I. 1970. The Heron *Ardea cinerea* and pollution. *Ibis* **112**:147-148.

REESE, J. G. 1970. Reproduction in a Chesapeake Bay Osprey population. *Auk* **87**:747-759.

SCHMID, F. C. 1966. The status of the Osprey in Cape May County, New Jersey between 1939 and 1963. *Chesapeake Sci.* 7:220-223.

TYRRELL, W. B. 1936. The Ospreys of Smith's Point, Virginia. *Auk* **53**(3):261-268.

WIEMEYER, S. N. 1971. Reproductive success of Potomac River Ospreys—1970. *Chesapeake Sci.* **12**(4):278-280.

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Sexing the Ameri
Using Secondary
Characteristics

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New York

Abstract: Body weight and tail ler
preys trapped in the northeastern
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heavier and have a longer tail thar
also taken of all trapped birds. It w
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Ospreys can be sexed in the field.

INTRODUCTION

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Carrying out the study ear
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BREAST PLUMAGE DIMOR

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